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Toxic Pollution from Powerplants: Large Emissions, Little Risk

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The Toxics Release Inventory (TRI) was established as part of the Emergency Planning and Community Right-to-Know Act of 1986. It requires production facilities in many different industries to report pounds of chemical emissions to air, water and land of substances on a Federally defined list if releases are above a specified level. The targeted chemicals are the so-called "toxics"; the TRI does not include, for example, the criteria air pollutants like sulfur and nitrogen oxides or particles. The annual summaries, posted on the Internet and reported in the news media, often show large quantities of emissions, raising concerns among the public and companies. Proponents of TRI suggest that emissions data can inform citizens about potential risks in their communities and encourage facilities to undertake pollution prevention efforts that will reduce risks.

The apparent success of TRI has stimulated great interest in expanding and increasing right-to-know activities. This issue of RISK IN PERSPECTIVE examines the relationship between TRI emissions and risk to human health, focusing on the electric utility industry, which is about to report TRI emissions for the first time. Although this industry will report large quantities of emissions, the resulting risk to public health is minimal. In addition, consideration of exposure and toxicity demonstrates that "pounds of emissions,, are a poor guide to risk management. This example illustrates why TRI should be revamped to consider risks as well as emissions.

Electric Utilities - From Emissions to Risk

In 1999, for the first time, electric utilities in the USA will report to the Environmental Protection Agency (EPA) their previous year's emissions of chemicals on the official TRI list. These emissions come from the burning of coal, oil, or natural gas to produce electricity. Many of these emissions have been the subject of risk assessments by EPA and the Electric Power Research Institute (EPRI). The EPA and EPRI assessments focused on hazardous air pollutants (HAPs), a category that includes almost all TRI emissions the utilities will report. Additionally, many utility companies have undertaken their own risk assessments of actual TRI emissions.

We use as an example an assessment of a large coal-fired powerplant in the eastern US. With this information we can compare emissions to risk. TRI includes emissions to air, land and water but we focus on risks from inhaling the air emissions (by far the largest source) from powerplants. There are other pathways of exposure, such as eating food grown in soil where pollutants deposit, that may be of importance for some substances.

Data for this issue of Risk in Perspective are taken from three sources: The EPA risk assessment of power generating plants mandated by the Clean Air Act Amendments of 1990 and reported to Congress in February of 1998; The EPRI report on the human health risks of HAP emissions from each of the approximately 600 powerplants in the U.S; and a site-specific assessment of TRI substances from a specific utility's generating plant.

How Risks Are Assessed

Risk assessments use emissions data as input into mathematical models that predict the concentration of pollutants in the air around a plant. These models also incorporate data on local geography, powerplant characteristics (like the height of the smokestack) and weather (e.g., wind direction and speed) to calculate air concentrations (in parts per million) of each pollutant within a 50 kilometer radius of the plant or even further away.

The amount of a substance that a person takes into her body is based on predicted air concentrations and a series of assumptions about personal activities. The EPA risk assessment focused on the Maximally Exposed Individual (MEI). The hypothetical MEI lives her entire life outdoors at the point of highest pollutant concentration. For some power plants, no one lives at the point of highest concentration, and rarely does anyone live in the same place for 70 years. Similarly, the assumption of an entire life lived outdoors is pessimistic because, for most pollutants, only a fraction of the concentration in outdoor air becomes part of air indoors. Thus, assumptions used to compute MEI exposure are considered to be conservative, likely to overestimate rather than underestimate exposure.

In addition to the MEI, the EPRI analysis computed exposures for a Reasonably Exposed Individual (REI). Among other differences, the REI included data on the time people spend indoors and outdoors and the penetration of outdoor pollutants inside. Using data from a survey of the movement of American households, it was also assumed that any one person lived near a power plant for 19 years. The MEI exposure estimates at the point of highest pollutant concentration were five to twelve times higher than those for the REI.

To estimate risk, exposure must be related to the toxicity of a substance. All of the risk assessments focused on long-term exposure and used standard EPA-type methods to characterize potential cancer risks and risks of other adverse health effects. For noncancer effects, exposure is compared to the reference concentration (RfC) or reference dose (RfD), a level of exposure determined by EPA that is expected to have no adverse effects with lifetime exposure, even among potentially sensitive subpopulations such as children and the elderly. The resulting hazard quotient (HQ) is simply the ratio of exposure to the RfC (or RfD). The HQ is not a probability. It is a ratio of dose to the apparently safe level; its reciprocal is like a safety factor (how many times the exposure is below the safe level). For compounds with carcinogenic potential, exposure is multiplied by a cancer slope factor to yield estimates of increased probability of developing cancer. Standard procedures for cancer risk assessment yield what EPA terms "a plausible upper bound" on risk; reminding us "the true risk is likely to be lower and may be zero."

Emissions vs. Risk

The risks from powerplant emissions will differ according to the fuel they use. Both EPA and EPRI analyzed coal, oil, and natural gas plants separately. Natural gas is the cleanest fuel and emissions from gas plants were so low that detailed analysis was not conducted. Not surprisingly, gas-powered plants are exempt from TRI reporting. Emissions from coal- and oil-fired power plants were analyzed more carefully.

The risk assessments show that human exposures to HAP emissions from powerplants were always well below the RfC (or RfD) for noncancer effects. Even the MEI exposure estimates were always less than 10% of the RfC. For the majority of compounds, MEI exposures were hundreds or thousands of times lower than the RfC, no matter which fuel the plant used. Both EPA and EPRI concluded that powerplant TRI emissions do not pose a risk of noncancer effects, even accounting for exposures to people living in areas subject to emissions from several plants.

Two measures of cancer risk from HAPs were examined: (1) individual risk, the increased probability (above background) of an individual developing cancer due to the exposure; (2) population risk, the annual excess number of cancers in an exposed population. The maximum individual risk (calculated with MEI exposure estimates) varied by plant fuel, location, age and other factors. According to the EPA report, all power plants had maximum individual risks below $1\text{x}10^{-4}$ and more than 97 percent had risks below $1\text{x}10^{-6}$. For coal-fired plants, 44 had an maximum individual risk below $1\text{x}10^{-8}$, 289 were between $1\text{x}10^{-8}$ and $1\text{x}10^{-7}$, 91 were between $1\text{x}10^{-7}$ and $1\text{x}10^{-6}$, and 2 plants had maximum individual risk estimates between $1\text{x}10^{-6}$ and $1\text{x}10^{-5}$. The distribution of estimates for oil-powered utilities was 26 with maximum individual risk below $1\text{x}10^{-8}$, 48 between $1\text{x}10^{-8}$ and $1\text{x}10^{-7}$, 52 between $1\text{x}10^{-7}$ and $1\text{x}10^{-6}$, 9 plants had maximum individual risk estimates between $1\text{x}10^{-6}$ and $1\text{x}10^{-5}$, and 2 plants were between $1\text{x}10^{-5}$ and $1\text{x}10^{-4}$. The EPA report suggests that the risk to the average individual is likely 100 to 1000 fold lower than the calculated maximum individual risk.

In all reports, population risks within 50 kilometers, based on census data near the powerplants, were very small. For example, even with all of the conservative assumptions, the EPA analysis concluded the upper bound risk from all coal plants in the U.S. (N = 426) was no more than 0.2 cases of cancer per year. Increasing the radius for analysis well beyond 50 kilometers increased the estimate of population risk about 7-fold due to the much larger population considered.

The HAP risk assessments do not completely overlap the list of TRI chemicals. Several substances that utilities will report under TRI were not included in the HAP assessments (barium, copper, molybdenum and zinc). In addition, several powerplant HAPs will not be reported under TRI because they do not meet reporting benchmarks.

Table 1

Compound	**TRI Emissions (pounds/year)**	**MEI Non-Cancer Hazard Quotient**	**MEI Individual Cancer Risk**
Antimony	360	8.57E-07	
Arsenic	3,640	4.00E-03	2.58E-07
Barium	820	4.57E-06	
Beryllium	380	3.00E-04	1.44E-08
Chromium	500	2.60E-05	3.12E-08
Cobalt	160	1.91E-06	
Copper	940	1.42E-05	
Hydrochloric Acid	5,172,000	2.18E-03	
Hydrofluoric Acid	46,480	9.75E-05	
Lead	960	4.43E-06	
Manganese	180	6.00E-05	
Molybdenum	500	6.40E-05	
Nickel	300	6.00E-06	3.12E-11
Selenium	6,860	3.96E-04	
Sulfuric Acid	2,915,200	5.36E-04	
Zinc	1,360	2.80E-06	
TOTAL	**8,150,600**	**0.008**	**3.04×10^{-7}**

**These ratios are in scientific notation. For example, the HQ for Antimony is 0.000000857, indicating exposure approximately 1.16 million times lower than the RfD or RfC.*

A Specific Example

Drawing on the experience of the HAP assessments, a major eastern utility company recently assessed short-term and long-term health risks due to TRI air emissions from their large coal-fired plants. Based on 1997 operating characteristics, their largest TRI emitting plant burned almost 7 million tons of eastern coal and produced over 16 billion kilowatt-hours of electricity (approximately equal to the total demand of Maine, New Hampshire and Vermont). The assessment was based on standard EPA methods, including calculation of the hypothetical MEI. Acute and chronic hazard quotients and cancer risks were calculated with values from EPA, when available. In the absence of official EPA values, exposure limits from California

EPA or the American Conference of Governmental Industrial Hygienists were used. TRI emissions and risk estimates are in the following table.

Looking at the table, we can imagine that the TRI Emissions column is similar to what will appear in the local newspaper when EPA releases the 1998 TRI emissions report. The next two columns show the chronic risk associated with those emissions. At the bottom, hazard quotients and cancer risks have been summed to characterize the overall risk from the plant. Acute risks were also assessed and the sum of acute hazard indices was less than 0.04. Along with the very low levels of risk associated with the emissions, a key insight from this table is the poor correlation across chemicals between pounds of emissions and levels of non-cancer or cancer risk.

Risks in Context

Few people, risk analysts included, have an intuitive feel for the sort of risk estimates in the table. Hazard quotients near or above 1, indicating exposure close to or exceeding the limit of an assuredly "safe" level, are generally of concern to regulators. Here, all HQs are far below 1. The cancer numbers are estimates of the upper-bound increase in cancer risk due to exposure at the MEI level. EPA and State Agencies use these sorts of risk numbers in regulatory practice all the time. In virtually every case, a risk estimate less than $1X10^{-6}$ (one in a million) is considered negligible by regulatory agencies. Here, all cancer risks are below the one in a million benchmark. To put this risk in context with other involuntary risks, $1X10^{-6}$ is 4 times smaller than an individual's lifetime risk of being killed on the ground by a falling aircraft and 100 times less than the risk of being struck by lightning or drowning in a home bathtub. And remember, the true value of the cancer risks, to quote EPA, "…is likely to be lower and may be as low as zero."

What Do We Learn?

I suggested in a previous Risk in Perspective (HCRA RIP Vol.5, No.4, April 1997) that the assessment of risk is the appropriate approach for right-to-know. The proactive approach of the electric utility industry has provided us with an opportunity to compare risks to TRI emissions.

The first lesson we learn is that large numbers of pounds of emissions are often associated with very small risks, even using very conservative screening methods of risk assessment. It is important to note, however, that certain compounds with MEI risks around $1X10^{-6}$ in the EPA and EPRI hazardous air pollutant analyses are not reported in the TRI. These substances are emitted below the reporting threshold. The only information that the public has received in the past is pounds of emissions. Clearly this is insufficient and potentially misleading. Few citizens have the means, interest or time to critically evaluate the necessary science to make TRI useful. For facilities, risk management efforts guided by emissions may be counterproductive. Efforts to reduce the largest emissions may provide little or no benefit to human health or the environment while smaller, possibly riskier, emissions are ignored. The solution is to put right-to-know information on a sound scientific footing through risk assessment.

Another lesson is that the way in which risks are assessed matters. When assessing risks to inform citizens and guide pollution prevention decisions, do "conservative" methods serve any purpose? Our goal should be doing the best job we can to estimate risks. For example, the EPRI analysis found significant differences between maximum and reasonable exposure estimates and EPA suggested that the maximum risk estimates might overstate average risk by

100 to 1000-fold. Deliberately inflating risk estimates, as in the maximum individual risk calculation, does not provide the best risk communication or management information. We must strive to develop the most scientifically appropriate methods to guide risk assessment for right-to-know.

Finally, it is clear that an industry that does its homework is in much better position to communicate with facility neighbors and to make sound pollution prevention decisions. For too long, many industries have relied on the TRI to guide their actions despite knowledge of its shortcomings. With the proliferation of right-to-know programs and proposals, we must pledge to bring science and context to the discussion.

Revamping the TRI program to report risk as well as emissions would be a first step. Listing risks right along with emissions would facilitate risk communication and management. It would not, however, address the question of compounds that might be of concern but aren't emitted in sufficient quantity to trigger TRI reporting. Simply lowering the reporting threshold cannot be the solution to this problem because it would flood the TRI system with emissions data on even more substances of negligible risk in order to include a few that might be of concern. A much better solution would be a significant-risk cutoff for reporting of all emissions, not only those on the TRI list. If facilities only reported emissions with cancer risks above $1X10^{-6}$ or HQs above 0.10, for example, reporting would be much more meaningful for citizens and company risk managers.

This system would require agreement on appropriate risk assessment methods and oversight to ensure compliance, but the result of such a program will be scientifically sound TRI, allowing more honest risk communication and better risk management.

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FURTHER READING

US EPA (1998) Study of Hazardous Air Pollutant Emissions from Electric Utility Steam Generating Units - Final Report to Congress. EPA-453/R-98-004a

EPRI (1994) Electric Utility Trace Substances Synthesis Report. EPRI TR-104614

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The Upcoming Precautionary Principle Conference

On June 3rd and 4th, 1999 in Washington, DC, the Harvard Center for Risk Analysis will be sponsoring an invitational workshop entitled "**The Precautionary Principle: Refine It or Replace It?**". The "precautionary principle" is playing an increasingly influential role in public policy toward technologies that pose potential risks to public health, safety, and natural resources. The purpose of the workshop is to stimulate scholars and practitioners to consider how the desire for precautionary action should be addressed in both analytical and deliberative processes aimed at informing public and private decisions that will affect health, safety, and the environment. The workshop will begin with an introductory panel on the history of the precautionary principle, including definitions, rationale, applications, and implementation issues. We will then learn from four panels that will examine the role of the precautionary principle in the following regulatory case studies: biotechnology, synthetic chemicals, electric and magnetic fields, and global climate change. A final panel will discuss the ramifications of the precautionary principle for both the use of formal analytical tools and the selection of processes for public deliberation. In addition to the invited speakers and discussants, we anticipate an audience of about 100 opinion leaders, stakeholders, and public servants. More information about this conference will be coming soon!